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Contributed paper

Nanometre multi-axis manipulator with interferometer control

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As one of the latest beamlines at the Synchrotron Radiation SOLEIL facility, ANTARES beamline will offer an X-ray nanoprobe able to combine four powerful non-destructive techniques: (i) angle-resolved photoemission spectroscopy, (ii) core-level photoemission (X-ray photo electron spectroscopy), (iii) X-ray absorption spectroscopy and (iv) X-ray fluorescence. ANTARES microscope has implemented a powerful and innovative nano-scanning photoemission microscope technique using three independent detectors in combination with a 14 integrated-axes manipulator. Microscope motion requirements involve linear and rotary positioning based on non-magnetic ceramic servo motors, compatible with ultra-high-vacuum conditions. A complete four-head interferometer system monitors continuously, with nano-metric precision, the alignment of the sample and focalization optics during the scanning operation. An accurate electronic feedback avoids image distortion due to mechanical vibrations or thermal effects.

1. INTRODUCTION

A wide range of structural and chemical imaging techniques are now available for research in advanced material science. In such context, ANTARES is attempting to extend nano-scanning photoemission microscope technique to the domain of low photon energy using angle-resolved photoemission spectroscopy (ARPES). In essence, this new beamline of SOLEIL will fit the existing emptiness between the atomic information provided by the scanning tunneling microscopy (STM) spectroscopy and the low spatially resolved data supplied by traditional ARPES and X-ray absorption spectroscopy techniques.

2. OVERALL DESCRIPTION OF THE ENDSTATION

A spatial-scan 5-axis sample manipulator with nanometre precision (better than 60 nm) controls the angular and spatial location of the sample. The sample environment is fitted with heating and cryogenic cooling (better than 15 K). A set of three Fresnel zone plates (FZP) and three order selection apertures (OSA) are used to cover the whole energy range. The FZP and the OSA are mounted on a separate

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high-resolution stage and provide the nano-sized focal point used to illuminate sequentially the studied material. The manipulator stages are located inside the vacuum vessel supporting the analyser, while the interferometers used for position control are outside the vessel in separate low-vacuum chambers.

3. DESCRIPTION OF THE MANIPULATOR

The three main manipulator stages (sample, FZP and OSA) are located on a common plate linked to the granite stand through the bottom flange of the vessel by use of bellows and columns (Figure 1).

The sample manipulator features eight axes:

- three translations used for sample positioning or 'off beam' operation;
- two rotations for angle scanning;
- three axis on piezo stage used for sample scan.

FZP and OSA stages are identical and feature three axes each:

- X and Z translation used for positioning the FZP or the OSA on the beam axis, the Z movement being used also to switch from one FZP or OSA to another (three positions).
- *S*-axis is used to adjust the focal point on the sample during energy scan operation.

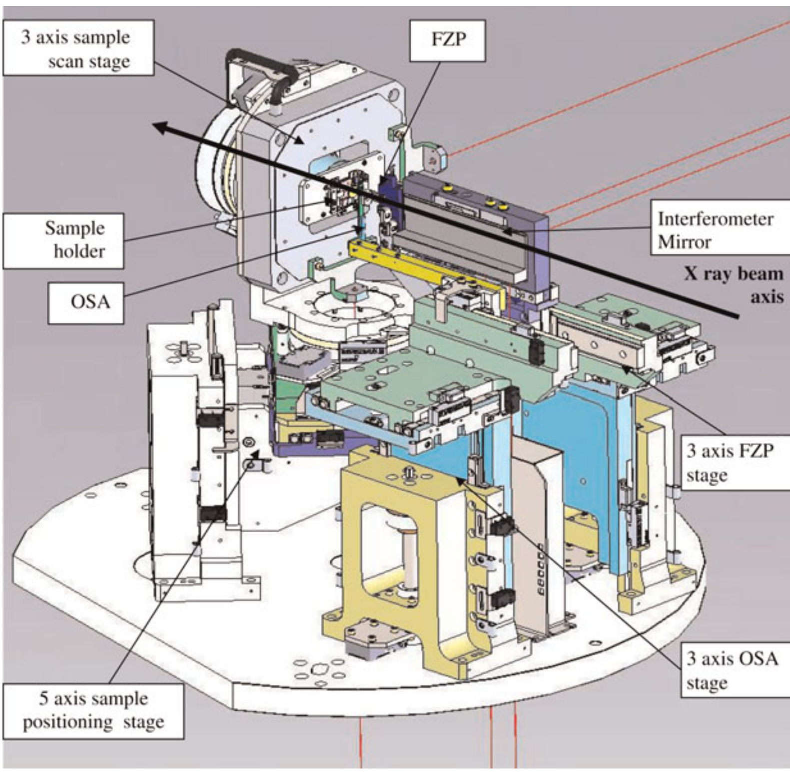

FIGURE 1. Overall view of the manipulator.

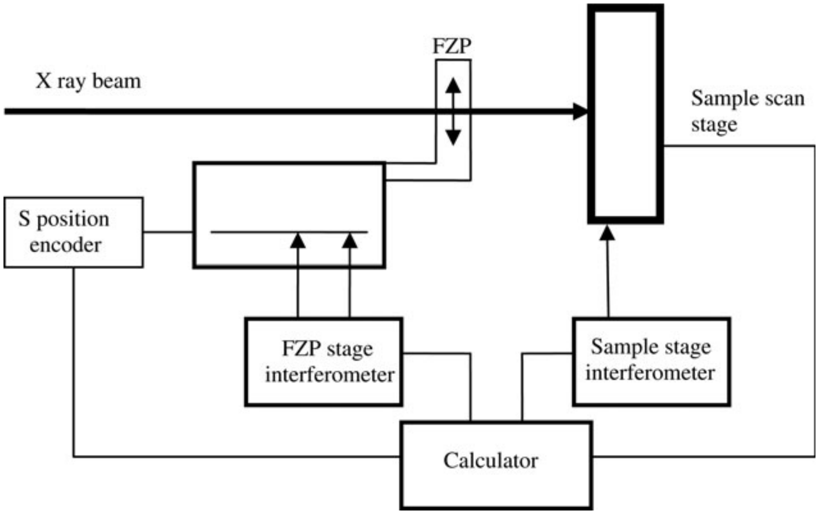

FIGURE 2. Schematic of interferometer control.

4. INTERFEROMETER CONTROL

During energy scan operation, the X-ray beam is normal to the sample and the FZP moves along the *S*-axis (X-ray beam axis) in order to keep the focal point on the observed surface. Ideally, this point should not move along transverse directions. In fact, considering operation at the sub-micron level, the spurious movements of the FZP holder stage induce transverse displacements (along X and Z) of the focal spot.

In order to correct these movements, the system implements nanometre range measurements using two sets of two interferometers in horizontal and vertical plane. In each plane, one interferometer monitors the position of the sample stage, while the other measures the spurious rotation and transverse translation of the FZP stage on the full operating travel. As the FZP is located on a lever arm at a variable distance from the measurement point of the interferometer, the actual movement must be calculated. A real-time calculation is performed using the interferometer signal and the S position of the FZP given by the stage encoder, and a correction value is applied to the sample scan stage (Figures 2 and 3).

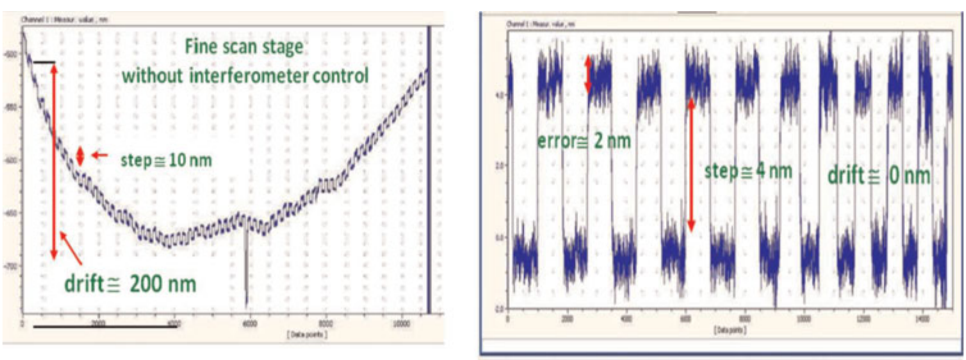

FIGURE 3. Sample motion without and with interferometer control.